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(54) **Method of and apparatus for forming a reinforced can end.**

(57) A method of forming a reinforced pressure-resistant can end comprising the steps of taking a blank (B), deforming it in a first deformation step to form a flanged cup-shaped configuration having a central portion (CP), a radius, frusto-conical wall, and annular flange and then deforming it a second time to offset the central portion (CP) and flange towards a common plane, to transform the radius into a reinforcing bead (Rr), the two deformation steps being carried out using two pairs (26, 36 and 60, 80) of coaxial relatively movable metal forming tools at the same work-station.

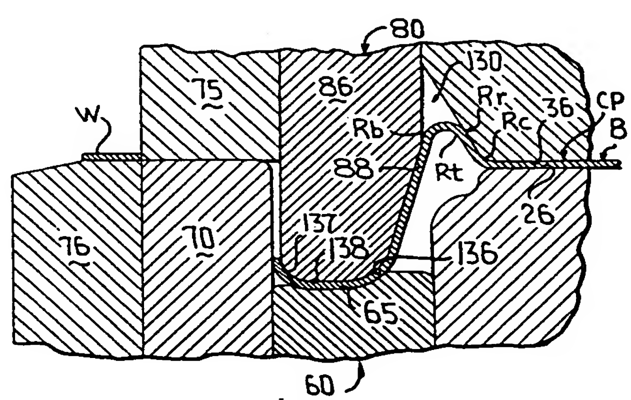


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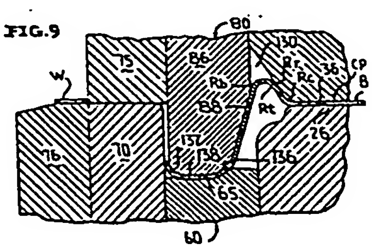
FIG.9

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# EUROPEAN SEARCH REPORT

Application number

EP 85 30 0879

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| D,A | US-A-4 109 599 (SCHULTZ) | | B 21 D 51/44 |
| X | US-A-3 537 291 (HAWKINS) * Claims 1-3, 8; figures 4, 6, 7 * | 1,2,6 | |
| A | US-A-4 372 720 (HERDZINA) * Claims 1-3 * | 1 | |
| A | US-A-3 957 005 (HEFFNER) | | |

| TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
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| B 21 D 51/00 |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 22-08-1985 | SCHLAITZ J |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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METHOD OF AND APPARATUS FOR FORMING A REINFORCED CAN END

The present invention is directed to a method of and apparatus for forming a can end which is highly resistant to internal pressure when seamed to a product-containing can.

Typical of one conventional method of manufacturing so-called pressure resistant can ends is that disclosed in Patent No. 4,109,599 in the name of Freddy R. Schultz issued August 29, 1978 and assigned to Aluminum Company of America. In accordance with one method disclosed in this patent, a sheet metal blank is positioned between a pair of dies which are moved to shear an edge of the blank after which a punch descends to form the now circular blank about an annular ring into an end shell having a peripheral flange, a frusto-conical wall, a radius and an end panel. The end shell is then removed from the first set of dies and inserted into a second set of dies in which the peripheral flange is curled into a downward peripheral flange suitable for double seaming operations.

The end shell is then placed between another pair of dies which when moved toward each other form the radius into a reinforcing channel or annular groove adjoining the simultaneously formed domed central panel. The so-called reinforcing channel or annular groove increases the pressure-resistance of the can end because of the reinforcement created by the increased depth of the annular groove with respect to the central panel and the tight radius of curvature of the latter. This type of reinforcement is said to make it possible to reduce the gauge thickness of a can end about 10 to 20 percent while maintaining pressure resistance capabilities of a conventional can end. However, the patent also acknowledges two dichotomous principles which are at work in the manufacture of a pressure resistant can end of this type, namely, the deepening of the annular groove and the

tightening of its radius act to increase pressure resistance, but the drawing operation has the effect of thinning the metal which acts to decrease pressure resistance.

While the objectives of conventional methods and apparatus are acknowledged herein, it is also important to recognize that such known methods also include other disadvantages, particularly when a blank or end shell must be transferred between a first set of dies to a second set of dies which virtually necessarily create alignment and/or tolerance problems, not to mention the simple fact that the transfer itself adds time to an overall forming operation simply because of the time involved in the transfer per se. Furthermore, it is not uncommon to lacquer the blanks prior to any forming operation, and forming in different dies and/or transferring between dies increases the tendency of the lacquer or enamel to crack or otherwise expose the metal to the eventual product packaged within a can to which the end has been seamed. The latter can result in undesired product deterioration.

Another disadvantage of forming a pressure-resistant can end in a series of different dies between which the blank must be transferred is simply the inability to maintain acceptable tolerances, particularly relative to overall concentricity, flange height and hook length. These three factors collectively establish to a large measure the eventual uniformity of successful double seaming which, once again, can be critical to product shelf life and/or longevity.

It is an object of the present invention to provide a novel method of and apparatus for forming a reinforced pressure-resistant can end within a single set of dies and in the absence of any type of transfer or movement

of the metallic blank once a forming operation has begun by utilizing the single set of dies to localise selectively an increased thickness of metal at a juncture at an outer frusto-conical peripheral wall and a reinforcing countersink radius of the can end, while at the same time localising a thinner flexible wall portion between a penel radius and a circular central panel of the can end to provide thereby an increased reinforcement in the absence of metal exposure, flexibility to transfer or absorb forces, and optimum tolerance including flange height, hook length and concentricity.

According to a first aspect of the invention, there is provided a method of forming a reinforced pressure-resistant can end comprising the steps of providing a substantially planar metallic blank having a central portion and a peripheral portion, deforming the blank in a first deformation step to cause relative movement in a first direction between the central and peripheral portions to offset said portions out of a common plane, thus shaping the blank into a generally flanged cup-shaped configuration defined by the central portion, a radius, a frusto-conical wall and an annular flange, and, in a second deformation step, causing relative movement between the central portion and annular flange in a direction opposite to said first direction, to deform at least a part of the metal of the radius, in the absence of restraint, out of the plane of the central portion and to a side thereof opposite the flange, thus transforming the radius into a reinforcing bead for the can end, characterised in that said first and second deformation steps are carried out by the use of coaxial relatively movable metal forming tools at the same work-station.

Suitably, the first deformation step is carried out by deforming the blank over a former comprising two spaced annular shoulders adapted to shape said radius so that it comprises a work-hardened edge region formed adjacent one of the shoulders, the work-hardened region of the radius providing, during the second deformation step, at least a part of the reinforcing bead with a wall thickness greater than the

wall thickness of the radius prior to the second deformation step.

The central portion or the flange of the cup-shaped configuration may be gripped during the second deformation step.

In one embodiment said first deformation step takes place in two stages, said first stage comprising turning the peripheral portion of the blank through approximately a right angle to form a skirt for the blank and said second stage comprising drawing the central portion relative to the skirt, which skirt is carried over an abutment member to transform it into the annular flange.

According to a second aspect of the invention, there is provided, apparatus for forming a reinforced pressure-resistant can end comprising means for creating a substantially circular planar metallic blank having a central portion and a peripheral portion, first force exerting means for exerting first forces against either the peripheral portion or the central portion of the blank in a first direction, first abutment means against which the central portion or the peripheral portion of the blank respectively abut during operation of the first force exerting means to deform the peripheral and central portions relative to one another, so that the portions are offset out of a common plane, thus shaping the blank into a generally flanged cup-shaped configuration defined by the central portion, a radius, a frusto-conical wall and an annular flange, second force exerting means for exerting second forces against either the flange or the central portion in a second direction opposite the first direction, and second abutment means against which the central portion or the flange respectively abut during operation of the second force exerting means to deform at least part of the metal of the radius in the absence of restraint out of the plane of the central portion and to a side thereof opposite the annular flange, thereby forming an annular reinforcing countersink radius, characterised in that the first and second force exerting means and first and second abutment means are all coaxial and are located at the same work-station.

Suitably, both said first and said second forces are exerted either against the peripheral portion of the blank and the annular flange respectively or against the central portion of the blank and the central portion of the cup-shaped configuration respectively.

Preferably, either the first force exerting means or first abutment means for cooperation with the central portion of the blank comprise a pair of spaced, coaxial shoulders for forming a work-hardened edge region and stretched central region of the radius.

Suitably, the second force exerting means or second abutment means for cooperation with the interior surface of the central portion of a cup-shaped configuration is contoured at its periphery to define with the other of the said second force exerting means or second abutment means an annular cavity selected to form therein a reinforcing bead of a predetermined radius of curvature.

Preferably, during operation of the second force exerting means, the second abutment means co-act with a further abutment means to grip therebetween either the central portion of the cup-shaped configuration or the flange.

According to a third aspect of the invention, there is provided a reinforced pressure-resistant can end, comprising a metallic blank having a generally circular centre panel, a panel radius joining the centre panel to a generally frusto-conical peripherally inner wall converging in a direction towards said panel radius and defining therewith and with said centre panel a generally interior frusto-conical chamber subject to internal pressure when the can end is flanged to an associated can body, an annular exteriorly opening reinforcing countersink radius joining said frusto-conical peripherally inner wall with a generally frusto-conical peripherally outer wall, said frusto-conical walls being in diverging relationship relative to each other in a direction away from said countersink radius, said outer frusto-conical wall merging with a flange adapted

to be seamed to a can body, said metallic blank having a nominal unformed thickness reflected by the cross-sectional thickness of unformed portions of said centre panel, characterised in that at least a portion of the cross-sectional thickness of said countersink radius is greater than the cross-sectional thickness of the unformed portions of said centre panel.

Preferably, said greater thickness portion of the countersink radius is immediately adjacent said outer frusto-conical wall.

Suitably, there is a flexible annular wall portion between said circular centre panel and said panel radius, and said flexible annular wall portion progressively thins in cross-sectional thickness from said circular centre panel to said panel radius, thereby transferring forces which might otherwise cause undesired distortion on use and/or impact of the can.

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:-

FIGURE 1 is a generally axial sectional view with some parts shown in elevation of a press including a punch and die, and illustrates as part of the punch a fluidically (preferably pneumatically) operated reform pad, and as part of the die an indent ring and a mechanically operated lift ring with the tooling shown at the completion of the first or forming operation in which a blank is formed to a generally cup-like configuration defined by a circular centre panel, a radius, a frusto-conical wall and an annular flange,

FIGURE 2 is an enlarged fragmentary schematic cross-sectional view of the draw punch, reform pad, indent ring and lift ring of Figure 1, and illustrates the latter in association with the panar metallic blank just prior to the blank being cut between a cutting punch and a cut edge of the die,

FIGURE 3 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 2, and illustrates a

further sequence in the operation of the punch during which the blank is cut between the cutting punch and the die cut edge,

FIGURE 4 is an enlarged fragmentary cross-sectional view of the tooling of Figure 3, and illustrates a generally convex axial end face of the draw punch applying downwardly directed forces to a peripheral edge portion of the blank,

FIGURE 5 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 4, and illustrates the position at which a central portion of the metallic blank is clamped between axial end faces of the reform pad and the indent ring,

FIGURE 6 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 5, and illustrates the simultaneous downward movement of the draw punch and the lift ring at which time a peripheral edge of the metallic blank is guided between respective convex and concave opposing surfaces of the draw punch and lift ring,

FIGURE 7 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 6, and illustrates the draw punch at the bottom of its stroke and a portion of the metallic blank bridging an annular outwardly opening groove of the indent ring,

FIGURE 8 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 7, and illustrates two phantom outlines and a single solid outline position of the can end during upward movement of the draw punch and lift ring at which time the flange is gripped between the lift ring and the draw punch and the previously formed radius of the can end is progressively formed into a reinforcing countersink radius,

FIGURE 9 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 8, and illustrates the position of the tooling at which the reinforcing countersink radius has been fully formed,

FIGURE 10 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 9, and illustrates in solid outline the release of the gripping forces by the retraction of the reform pad and in phantom outline the position of the lift ring prior to final ejection of the fully formed can end,

FIGURE 11 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 10, and illustrates the punch and die fully opened and the lift ring at a position permitting ejection of the completed can end,

FIGURE 12 is a fragmentary cross-sectional view of a reinforced pressure resistant can end constructed in accordance with this invention, and illustrates in conjunction with a graph a variety of different wall thicknesses thereof pertinent to the present invention,

FIGURE 13 is an enlarged fragmentary schematic cross-sectional view of a modified form of tooling of the invention at the same position as that illustrated in Figure 7, and illustrates a modification of the reform pad in which a peripheral surface and a terminal end face are bridged through a radius, a cylindrical surface and an angled surface,

FIGURE 14 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 13, and illustrates the manner in which the radius formed by the tooling of Figure 13 is reformed by the upward movement of the lift ring and draw punch into an annular area set off in part by the reform pad and angled and cylindrical surfaces,

FIGURE 15 is a generally fragmentary axial sectional view of another press including another punch and die, and illustrates the tooling thereof in a position forming the configuration of the can end or shell of Figure 18,

FIGURE 16 is an enlarged fragmentary schematic cross-sectional view of a draw punch, reform pad, indent ring and lift ring of Figure 15, and illustrates the latter in association with a metallic blank which has been cut between a cutting punch and a cut edge of the die,

FIGURE 17 is an enlarged fragmentary cross-sectional view of the tooling of Figure 16, and illustrates a further sequence in the operation of the punch during which the blank is formed into a shallow cup having a central portion and annular skirt,

FIGURE 18 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 17, and illustrates the tooling at the bottom of its stroke after the shallow cup of Figure 7 has been reformed to an oppositely opening flanged cup, and

FIGURE 19 is an enlarged fragmentary schematic cross-sectional view of the tooling of Figure 18, and illustrates the position of the tooling at which a reinforcing countersink radius has been fully formed.

The invention will be best understood by first referring to Figure 1 of the drawings which illustrates a portion of a conventional multi-die double action press which is generally designated by the reference numeral 10. The press 10 includes a punch 11 and a die or bolster block assembly 12. The bolster block assembly 12 is a stationary portion of the frame (not shown) of the press 10 while the punch 11 is reciprocated in a conventional manner, as by eccentrics or cams between a fully

closed or bottom dead center position (Figure 1) and a fully opened position (Figure 11).

The die or bolster block assembly 12 includes a generally cylindrical upwardly opening recess 13 housing a draw die base 14 which is secured to the assembly 12 by a plurality of hex screws 15 received in a plurality of counter-bored bores 16 and threaded in threaded bores 17 of the assembly 12. There are six such bores 16 and hex screws 15 equally spaced about the draw die base 14 and six similarly spaced threaded bores 17 formed in the assembly 12 for securely attaching the draw die base 14 to the assembly 12 within the recess 13. A bottom wall (unnumbered) of the draw die base includes an axial bore 18 in which is reciprocally moved an upper portion 20 of a knock-out lift ring rod 21.

The bottom wall (unnumbered) of the draw die base 14 also includes four counterbores 22 of which only one is illustrated in Figure 1, and a hex screw 23 is received in each counterbore 22 and is threaded in a threaded bore 24 of an indent ring 25 seated within a shallow upwardly opening circular recess 29 of the draw die base 14. The indent ring 25 and a reform pad or draw punch gripper pad 35 of the punch 11, which will be described more fully hereinafter, cooperate to collectively define therebetween means for gripping a central panel <u>CP</u> (Figure 2) of a metallic uniplanar blank <u>B</u> having at outer peripheral edge or peripheral edge portion <u>PE</u>. Essentially, the central portion or center panel <u>CP</u> of the blank <u>B</u> is gripped between a relatively flat terminal circular end face 26 of the indent ring 25 and a similar flat circular terminal end face 36 of the reform pad 35 (Figure 2).

The indent ring 25 additionally includes a generally cylindrical or peripheral outer surface 27 and the surfaces 26, 27 are

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bridged by means 40 (Figure 2) for creating unrestrained tensioning of the blank B during the formation of a somewhat angulated radius R (Figure 7) defined by a pair of shoulders or radius portions Rb and Rc spanned by an annular generally flat angled wall portion Rt (Figure 7). The tensioning means 40 includes a pair of annular shoulders 41, 42 between which is an outwardly opening annular groove 43. The radii of the shoulders 41, 42 are respectively .030" and .065", while the radius of the annular groove 43 is .010". The distance of the axis for the radius of the shoulder 42 from the axial terminal end face 26 of the indent ring 25 is .015" and the distance of the axis of the radius 41 from the axis of the indent ring 25 is approximately .976" - .977".

A lower portion (unnumbered) of the indent ring 25 is traversed by a diametric slot 28 which transforms a lower end portion of the indent ring 25 into a pair of legs 30, 31. The diametric slot 28 accommodates reciprocal movement of a hub 105 forming part of a diametric spider (not shown) of a lift ring 60 which will be described more fully hereinafter. However, each of the legs 30, 31 of the indent ring 25 includes a vertical slot 32, 33, respectively, functioning as a vertical limit for reciprocal motion of the lift ring 60.

The draw die base 14 also includes six equally circumferentially spaced bores 34 and six equally circumferentially spaced blind bores 45. Each of the bores 34 receives a reduced end portion 46 of a lift pin 47 while each of the blind bores 45 houses a compression spring 48.

The compression springs 48 bear against the undersurface (unnumbered) of a conventional draw die 70 which cooperates in a conventional manner with a cutting punch 75 of the punch 11 and a cut edge or annular blanking die 76 carried by a die holder or

die assembly 78 secured in a conventional manner to the bolster block assembly 12 by a plurality of hex socket screws and nuts 81. Upon the descent of the cutting punch 75, which will be described more fully hereinafter, upon conventional downward motion imparted to the punch 11, the cooperative interaction of the draw die 70, the cutting punch 75 and the cut edge 76 results in the peripheral edge PE of the blank B being blanked or trimmed to a circular configuration as defined by a cut edge CE with, of course, waste material W being eventually discarded during normal operations of the press 10.

The lift ring 60 includes an outer peripheral cylindrical surface 61 and an inner peripheral cylindrical surface 62 which has a groove (unnumbered). The lift ring or annular forming member 60 includes a terminal peripheral end face 64 (Figure 2) bridging the peripheral surfaces 61 and 62. The terminal peripheral end face 64 includes a shallow upwardly opening convex recess 65, and inboard annular axial face or surface 66 and an outboard annular axial face or surface 67. The surface 66 is radially longer than and slightly above (.030") the surface 67. The collective surfaces 65 through 67 provide guidance to inward metal flow of the peripheral edge portion PE of the blank B during the downward or forming stroke of the operation and a clamping or gripping action during the upward or reforming stroke, as will be described more fully hereinafter. Downward movement is imparted to the lift ring or annular forming member 60 by the descent of the draw punch 80. During such downward movement, the lift pins 47 are also moved downwardly moving a lift pin disc 91 out of contact with a bumper retainer plate 92 and further compressing a previously preloaded spring 93 to load the spring 93 to approximately 2,000 lbs. force. The same

downward movement of the lift pins 47 and the lift pin disc 91 is transferred to a lift pin spacer 94 which compresses a compression spring 95. The springs 93, 95 operate in a conventional manner, but the same will be described more completely hereinafter.

The bumper retaining plate 92 is secured to the bolster block assembly 12 by a plurality of hex socket screws 96 received in counterbores 97 of the bumper retainer plate 92 and threaded in threaded bores 98 of the bolster block assembly 12. The bolster block assembly 12 also includes a threaded bore 101 into which is threaded an enlarged threaded portion 102 of a lift ring knock-out bumper pad 103 having an axial bore 104 within which reciprocates the knock-out lift ring rod 21.

The punch 11 includes a conventional blank punch slide assembly 110 which has mounted thereto a conventional cutting punch holder 111 by means of a blank ram attachment 112 (only one illustraated) and an associated set screw 113. The cutting punch 75 is secured in a conventional manner, including a cutting punch holder clamping nut 114, to a lower end portion of the cutting punch holder 111.

An inner piston or draw punch rod 120 is mounted for reciprocal movement within the cutting punch holder 111 and includes a bore 121, a counterbore 122 and an internally threaded end portion 123. The internally threaded end portion 123 is threaded to a threaded portion 82 of a stem 83 of a draw punch 80. The draw punch 80 includes an axial bore 84 and a counterbore 85 defined by a peripheral skirt or annular forming member 86 of the draw punch 80. The counter bore 85 is defined in part by an inner cylindrical peripheral surface 87 which is in intimate sliding contact with a like outer peripheral cylindrical

surface 37 of the reform pad 35. The cylindrical surface 37 and the axial end face 36 of the reform pad 35 are bridged by means 38 in the form of an angled annular surface setting-off an obtuse angle of approximately 120° with the terminal end face 36. A like obtuse angle is set-off between the peripheral surface 37 and the angled annular surface 38. The means 38 functions to prevent a coating C, such as lacquer or enamel, from cracking or being wiped off and, thus, prevents metal exposure of the eventually formed inner surface of the blank B during the forming and reforming operation. The same means 38 or angled annular surface 38 cooperatively functions with a frusto-conical surface 88 (16°) of the draw punch 80 to define therewith and therebetween means for forming an annular downwardly opening and diverging chamber 130 into which the formed radius R (Figure 7) can be freely reformed without guidance or restraint (see Figures 8 and 9) during the upward stroke or movement of the lift ring or annular forming member 60 to form eventually an annular reinforcing countersink radius Rr, again as will be described more fully hereinafter.

The frusto-conical surface 88 merges with a pair of convex radii 136, 137 bridged by a generally flat annular surface 138. The curvature of the radii/surfaces 136 through 138 corresponds to the curvature of the surface 65 of the groove 64 which together therewith provides added guidance to the inward metal flow during the downward or forming stroke when the blank B is formed to its final formed (though not reformed) configuration (Figure 7).

A hex screw 140 is threaded into a threaded bore (unnumbered) of a draw punch shaft or piston 141 having a blind bore 142, a plurality of seals 143 and a peripheral flange 144

which can bottom against an annular axial end face 145 of the draw punch stem 83. The counterbore or chamber 122 is connected through the port 121 to a supply of fluidic pressure, such as a nitrogen cylinder and an associated regulator assembly or an air amplifier with appropriate valving and controls, which is simply designated by the headed arrow P1. The inner piston or draw punch rod 120 is likewise urged downwardly by fluidic pressure suitably regulated from the same or a different source as the pressure source P1, and the pressure applied to the draw punch rod is generally designated by the reference character P2 associated with the arrow in Figure 1, although pressures P1, P2 can be equal. The pressure P1 can be, for example, as low as 600 psi and at 1000 psi, the pressure on the piston 141 is approximately 1060 psi. The pressure is preferably higher, particularly the pressure P2 exerted in a downward direction upon the draw punch rod 120 because the latter pressure is transferred during the downward or forming stroke from the rod 120 through the draw punch 80, the lift ring 60 and the lift pins 47 to unseat the lift pin disc 91 and the lift pin saver 94 and, therefore, load the springs 93, 95 which upon the reform, return or upward stroke of the rod 120 provide the mechanical force to lift the rods 47 and the lift ring 60 upwardly to reform the blank B from the position shown in Figure 7 to that shown in Figure 9.

The operation of the press 10 will now be described with particular reference to Figures 2 through 11 of the drawings and, of course, it will be assumed that the blank punch slide assembly 110 of the punch 11 has been retracted upwardly to its open position (Figure 11) with the blank B positioned as shown in

Figure 2, but, of course, being supported upon the flat annular face 66 of the lift ring 60. The means for providing the pressures P1 and/or P2 have been activated and, therefore, the flange 144 of the draw punch piston 141 is bottomed against the annular face 145 (Figure 1) of the stem 83 of the draw punch 80. This positions the axial terminal face 36 of the reform pad 35 slightly above the flat annular surface 138 of the draw punch 80 (Figure 2). Upper end faces (unnumbered) of the lift pin disc 91 and the lift pin spacer 94 are in abutment with an undersurface (unnumbered) of the bumper retainer plate 92 (Figure 1).

Conventional eccentric or cam means lower the cutting punch holder 111 which causes the cutting punch 75 to contact (Figure 2) the peripheral edge portion PE of the blank B and then sever the same (Figure 3) forming the cut edge CE. At this position (Figure 3), the peripheral edge portion PE of the blank B is lightly gripped between the cutting punch 75 and the opposing draw die 70 which slightly compresses the springs 48.

The pressure P2 acting downwardly upon the rod 120 continues to move the draw punch 80 in a downward direction causing initial deformation of the peripheral edge PE of the blank B (Figure 4) without, at this time, the center panel CP being clamped between the faces 26, 36 of the respective indent ring and reform pad 25, 35. The peripheral edge PE is, however, progressively withdrawn inwardly from between the cutting punch 75 and the draw die 70 (compare Figure 3 and Figure 4).

The continued downward fluidic pressure P2 upon the rod 120 progressively moves the draw punch 80 downwardly (Figure 5) until a point is reached at which the surface 36 of the reform pad 35 contacts the center panel CP of the blank B and clamps the same in conjunction with the opposing surface 26 of the indent ring 25.

Thus, from this point (Figure 5) forward during the continuation of the first or forming operation, the central panel CP remains clamped between the reform pad 35 and the indent ring 25.

Eventually, the downward descent of the draw punch 80 reaches a position at which the force P2 is not only transferred to form the peripheral edge PE of the blank B, but also to act indirectly therethrough to force the lift ring 60 downwardly (Figure 6). During this action, the groove 64 and the surfaces 136 through 138 function to guide the inward metal flow as the blank B is progressively formed toward the eventual angulated radius R (Figure 7). From the position of the lift ring 60 shown in Figure 6 to that shown in Figure 7, the downward movement of the draw punch 80 not only forces the lift ring 60 downwardly but this force or pressure P2 is transferred from the lift ring 60 through the lift pins 47 (Figure 1) to the lift pin disc 91 and from the latter to the lift pin spacer 94, thus loading both springs 93 and 95 to obtain upon the return or reform stroke of the press 10 a mechanical force approximating 2000 lbs. Thus, in addition to loading the springs 93, 95, the draw punch 80 also forms the final configuration of the flange 160 (see Figure 12) and also forms the angulated radius R (Figure 7) by stretching or tensioning the central portion Rt between the radius Rb and Rc. As will appear more fully hereinafter, the tensioning in the area Rt is believed to provide the marked increase in flexibility of an annular wall portion 152 of a completely formed can end 150 (Figure 12) while the work hardening of the radius portion Rb coupled with its eventual reforming into the reinforced countersink radius Rr (Figure 9) results in a "kink" or an increased thickness portion beyond "nominal", thickness at a portion of a countersink radius 155 between the lines of

demarcation L6 and L7 of Figure 12. Thus, from the position generally shown in Figure 2 to that shown in Figure 7, the draw punch 80 moved forcefully downwardly by the pressure P2 is effective for exerting forces sufficient to transform the peripheral edge portion PE of the blank B to the configuration of the formed, though not reformed, blank B of Figure 7.

The reform or return stroke is initiated without any change in position of the blank punch slide assembly 110 and the cutting punch holder 111 and without in anyway reducing the clamping action against the center panel CP of the blank B between the gripping means 25, 35, i.e., the indent ring 25 and the reform pad 35. As the spring or springs 93, 95 urge the lift pins 47 upwardly against regulated decrease in the pressures P1 and/or P2 (Figure 8), a flange 160 of the can end 150 is clamped or gripped between the surfaces 136 through 138 of the draw punch 80 and the surface 65 of the lift ring 60 with a progressive upward movement causing the angulated radius R (Figure 7) to be deformed progressively out of the plane of the center panel CP of the blank B, as is shown in an initial stage in solid lines in Figure 8. By comparing Figures 7 and 8 it can be seen that the radius portion Rc of Figure 7 is generally reversed progressively from the position shown in Figure 7 to that which it eventually reaches in Figure 9 while at the same time the radius portion Rt is deformed progressively and without restraint, guidance or confinement into the annular channel or chamber 130 until the reinforcing countersink radius (Rr of Figure 9 or 155 of Figure 12) is fully formed. However, during the movement of the lift ring 60 and the draw punch 80 as aforesaid between the position shown in Figures 8 and 9, the earlier tension portion Rt of the radius R tends to deform or bend more readily as opposed to the

work hardened portion Rb which characteristically creates a relatively tight radius Rr and the reinforced thickened "kink" between the lines of demarcation L6, L7 (Figure 12).

Upon completion of the return or reforming stroke (Figure 9), the pressure P1 on the draw punch shaft 141 (Figure 1) is released or lessened and unclamping of the blank B occurs as the lift ring 60 continues its upward spring biased return under the mechanical force of the springs 93 and/or 95 until the phantom outline position of Figure 10 is reached by the lift ring 60. Thereafter, the cutting punch holder 111 is mechanically retracted to the final position shown in Figure 11 at which point the can end can be conventionally ejected.

Reference is now made to Figure 12 of the drawings which best illustrates the resultant reinforced pressure resistant can end generally designated by the reference numeral 150.

The can end 150 includes a generally circular center panel or panel portion 151, a flexible annular wall portion 152, a panel radius 153, a frusto-conical peripherally inner wall 154, an annular exteriorly upwardly opening reinforcing countersink radius or channel 155, a frusto-conical peripherally outer wall 156, a radius 157, an annular end wall 158 and a peripheral edge 159 with the latter three portions collectively defining a flange 160 which is utilized in a conventional manner to double seam the can end 150 to the can body.

A graph G has been associated with the can end 150 of Figure 12 to graphically illustrate the variation in cross-sectional wall thickness of the can end 150 from the central panel 151 to the frusto-conical peripherally outer wall 156. The graph G depicts the percentage of change in gauge or thickness along the ordinate and the abscissa depicts the change in gauge using the

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countersink radius 155 as the "0" point. The end is a 206 diameter "Carson" shell.

The gauge or cross-sectional wall thickness of the circular central panel 151 of the can end 150 is generally designated by the reference character Th and on the graph G, this "nominal" thickness is represented by the horizontal dash line at "100". A line L1 represents the point of demarcation between the circular central panel 151 and the flexible annular wall portion 152, although it must be recognized that the position of the line L1 is not exact but is amply adequate to understand the present invention and the variations in the gauge or wall thicknesses throughout the can end 150, as will be come clear hereinafter. A line l1 has been used to reference the line of demarcation L1 with a point P1 on the graph G to indicate that to the right of the point P1, the "nominal" or unformed thickness of the center panel 151 corresponds to the "nominal" thickness of the blank B prior to initiating the forming operation. A line of demarcation L2 indicates the outboard extent of the flexible annular wall portion 152 and the line l2 therefrom to the point P2 indicates on the graph G a progressive thinning of the cross-sectional thickness of the flexible annular wall portion 152 from point P1 to point P2.

Another line of demarcation L3 sets off with the line L2 the extent of the panel radius 153 with a center line of the panel radius 153 being designated by the line C3. A line l3 connects the line L3 with a point P3 on the graph G, while another line l4 connects the line C3 with a point P4 of the graph G. The configuration of the curve passing between the points P2 and P3 indicates the wall thickness or gauge of the panel radius 153 essentially decreases from the line L2 and then increases

at the area of the line C3 (Point P4) after which the cross-sectional thickness again abruptly decreases and increases toward the point P3 and the line L3. The increased thickness generally in the area of the point P4 as compared to the progressive thinning of the annular wall portion 152 between the points P1 and P2 renders the annular wall portion 152 somewhat more flexible than both the center panel 151 and the panel radius 153 thereby permitting the annular wall portion 152 to flex under abuse, excess internal pressure, or the like, without failure.

Another line of demarcation L5 sets-off the frusto-conical peripherally inner wall 154 with the line L3. A line l5 from the line of demarcation L5 to a point P5 establishes the progressive decrease in wall thickness or gauge of the frusto-conical peripherally inner wall 154 from a point just beyond point P3 toward, but not quite to, to point P5.

The reinforcing countersink radius 155 is set-off between the line of demarcation L5 and another line of demarcation L6 between the two of which is a line C4 representing the radius of the countersink 155 and a line C5 indicating the bottom of the countersink 155. Another line of demarcation L7 is illustrated radially inward of the line of demarcation L6. Lines l6 and l7 connect the respective lines L6, L7 with points P6 and P7, respectively, of the graph G. Similarly, lines l8 and l9 connect the lines C4, C5, respectively, with points P8 and P9, respectively, of the graph G. The significance of the latter described structure is the significant increase from the "nominal" thickness between the points P6 and P7 which results in a thickening, compression, or bulging of the material between the lines of demarcation L6 and L7 and slightly radially outwardly beyond the line L6. The material in this area is visibly

"kinked" exteriorly, and the exteriorly surface (unnumbered) of the portion of the countersink radius 155 and the frusto-conical wall 156 generally between the lines of demarcation L6 and L7 bulges outwardly beyond an outer surface 161 of the frusto-conical wall 156 which, of course, from the graph G is seen to progressively thin beyond point P6. The portion Rf of the countersink radius between the lines of demarcation L6 and L7 corresponds generally to the radius Rb (Figure 7) which is believed to be slightly work hardened during the initial forming operation, and this attendant loss of flexibility permits not only the unrestrained reforming (Figures 8 and 9) of the radius R to the configuration of the radius Rr in Figure 9, but also the accumulation of metal in this same area (between the lines L6 and L7). The increased thickness in the countersink radius 155 at generally the radially outboard portion Rf (Figure 12) of the can end 150 results in desired end reinforcement whereas the progressively thinner annular wall portion 152 results in desired end flexibility.

The can end 150 of Figure 12 is, of course, constructed in the absence of metal exposure, as was heretofore noted, and the coating C remains essentially homogeneous and uninterrupted on the inner surface (unnumbered) of the can end. This is, of course, achieved with flange height (F), flange length (Lf) and concentricity (D) (Figure 12) well within design tolerances.

Variations in the present method and apparatus will become apparent to those skilled in the art and such are considered to be within the scope of this disclosure including various modifications in or reversal of the various elements heretofore described. As an example, reference is made to Figures 13 and 14 which have been provided with like though primed reference

numerals to identify structure identical to that illustrated respectively in Figures 7 and 9. In this case, the reform pad 35' has been modified by altering the overall configuration of adjoining surfaces 170 through 172 bridging the surfaces 36' and 37'. The surface 170 is of an angular configuration, similar to the surface 38 of the reform pad 35. However, the surface 172 is radially outboard of the corresponding radius 41' of the indent ring 25' and as a result the annular downwardly opening chamber 130' abruptly narrows at the cylindrical surface 171. Thus, upon the return stroke or reform stroke upwardly of the lift ring 60', the radius R'r is "tighter", as is most readily apparent by simply comparing the radius Rr of Figures 9 through 10 with the radius R'r of Figure 14. This results in a more rigid reinforcement of the countersink radius 155' than that provided by the reinforcing radius 155.

It is also readily apparent and within the scope of the present invention to essentially reverse or flip-flop the position of the reform pad 35 and draw punch 80 relative to the indent ring 25 and lift ring 60. In other words, it is clearly within the scope of this invention to have the indent ring 25 and lift ring 60 carried by the draw punch rod 120 and the reform pad 35 and draw punch 80 carried by the die or bolster block assembly 12.

A modification as aforesaid is illustrated in Figure 15 of the drawing in which a press or tool assembly 210 is illustrated and comprises a punch or upper tool 211 and a die or lower tool 212. The upper tool 211 includes a cutting punch or sleeve 275, a holding ring or lift ring 260 within the cutting punch or sleeve 275 and a first draw punch 225. The components 225, 260 and 275 of the tool assembly 210 will be seen to correspond to the like components 25, 60 and 75 of the press 10. The lower

tool 212 includes a blanking die or cutting ring 276, a first draw die 280 surrounded by an annular ring 220 in alignment with the cutting sleeve 275 and a second or "redraw" punch or reform pad 235 within the first draw die 280. The elements 235 and 280 correspond to the elements 35 and 80 of the press 10.

The upper tool 211 is mounted in a top plate 262 of a pillar die set comprising at the top plate 262 a plurality of conventional guide pillars (not shown) and a bottom plate 252 which can reciprocate relative to the top plate 252 and during such movement is guided by the latter-noted pillars. The tool or die assembly 210 of Figure 15 is mounted in a "C" framed power press on a press plate 265 so that the top plate 262 is urged to reciprocate by the press ram (not shown) and the bottom plate 252 remains stationary on the press plate 265.

In use, a sheet of metal is placed between the upper tool 211 and the lower tool 212 and the tools are closed by movement of the press ram acting on the top plate 262 so that the cutting sleeve 275 cooperates with the cutting ring 276 to cut out a circular blank B'' (Figure 16) with the waste material being designated by the reference character W''. As in the case of the blank B of Figures 2 through 11 of the drawings, the blank B'' includes a center panel CP'' and a peripheral edge PE''.

After the cut out of the circular blank B'', continual downward travel of the press ram urges the top plate 262 of the die assembly to push the sleeve 275 downwardly and through the peripheral edge PE'' of the blank B'' also pushes the annular ring 220 downwardly toward the position shown in Figure 17. During the motion of the sleeve 275 and the annular ring 220 from the position shown in Figure 16 to the position shown in Figure 17, the peripheral edge PE' is formed over a convex surface 238

of the first draw die 280 with the sleeve 275 and the annular ring 220 functioning as a sprung blank holder from between which the peripheral edge PE'' is eventually withdrawn into the sandwiched relationship between the sleeve 275 and the die 280 to shape the peripheral edge PE'' into a shallow downwardly opening shallow shell SS (Figure 17) defined by a substantial cylindrical wall CW and the central panel CP''. The downward motion of the first drawing operation compresses a spring (not shown but corresponding to the spring 93 of Figure 1) through push rods 240 (Figure 15) so that the blank holding or clamping pressure between the sleeve 275 and the annular ring 220 is controlled as metal is drawn over the face 238 of the draw die 280 to form the inverted shallow shell or cup SS of Figure 17. The continued drawing moves the punch 225 and the second punch 235 downwardly toward the position shown in Figure 18 in which the blank B'' corresponds generally to the blank B of Figure 7, except, of course, the now cup-shaped blanks B, B'' open in opposite directions (downwardly in Figure 7 and upwardly in Figure 18). The central panel CP'' is, of course, clamped between the punch 225 and the punch 235 during the movement thereof from the position shown in Figure 17 to the position shown in Figure 18, and during this downward movement the peripheral edge PE'' is drawn over the convex edge 238 of the die 280, as earlier noted. It is after this formation of the peripheral edge PE'' toward the end of the stroke shown in Figure 18 that the holding ring 260 moves downwardly and now clamps the now formed cover hook or flange 260' (Figure 18) between the surfaces 238, 265 of the respective tooling elements 280, 260. The holding ring 260 is residentally urged to act against the flange 260' on the surface 238 of the die 280 by springs 239 (Figure 15) and rods 241 in the

upper tool 211 as the punch or indent ring 225 begins to retract upon the return motion of the press ram.

The return motion of the press ram permits the punch 280 to cooperate with the redraw punch 235 of the lower tool 212 which is urged by a compression spring (not shown but acting through a cross head and a plurality of rods 250) to progressively reform or deflect the center panel CP'' from the position shown in Figure 18 to that of Figure 19. The latter movement progressively generates the reinforced countersink raduis or anti peaking radius 255 by a folding action essentially identical to that heretofore described relative to Figures 8 and 9 of the drawings. Thus, the eventually formed end or shell 250 corresponds in structure and function identically to that heretofore described relative to the end or shell 150 (Figures 11 and 12).

A detailed construction of the various push rods and springs under the press plate 265 are readily understood by those skilled in the art who will also appreciate that springs such as those operating the rods 240, 250 could be replaced by other resilient devices, such as a gas cushion or hydraulic cylinders as forming operations may dictate. If preferred, a power press having a second powered action may be used.

Variations are also well within the scope of the invention as heretofore described relative to Figures 15 through 19 of the drawings, and one such variation is apparent from Figure 18 to which attention is now directed. If during the first downward movement of the draw punch 225, the motion were continued beyond the position shown in Figure 18 the frusto-conical surface 256 would merge with a cylindrical wall portion (not shown) before merging with the unnumbered radius of the blank B''.

When such a can end is reformed, the cylindrical portion CW' is pulled radially inward but any spring back of the fold of the radius or anti peaking bead 255 can be used to compensate for relaxing the curve of the anti peak bead.

In both the modification just described and that specifically described relative to the press 10, while it is highly desirable to use fluidic pressure (P1 and/or P2), it is also considered within the scope of this invention to selectively operate the draw punch rod 120 and the draw punch piston 141 through separate cams or eccentrics such that the springs 93 and/or 95 can be loaded during the forming stroke under mechanical as opposed to fluidic pressure. The reform pad 35 may also be biased downwardly by a mechanical spring rather than the fluidic/pneumatic pressure P1.

CLAIMS

1. A method of forming a reinforced pressure-resistant can end comprising the steps of providing a substantially planar metallic blank having a central portion and a peripheral portion, deforming the blank in a first deformation step to cause relative movement in a first direction between the central and peripheral portions to offset said portions out of a common plane, thus shaping the blank into a generally flanged cup-shaped configuration defined by the central portion, a radius, a frusto-conical wall and an annular flange, and, in a second deformation step, causing relative movement between the central portion and annular flange in a direction opposite to said first direction, to deform at least a part of the metal of the radius, in the absence of restraint, out of the plane of the central portion and to a side thereof opposite the flange, thus transforming the radius into a reinforcing bead for the can end, characterised in that said first and second deformation steps are carried out by the use of coaxial relatively movable metal forming tools at the same work-station.

2. A method as claimed in claim 1, characterised in that the first deformation step is carried out by deforming the blank over a former comprising two spaced annular shoulders adapted to shape said radius so that it comprises a work-hardened edge region formed adjacent one of the shoulders, the work-hardened region of the radius providing, during the second deformation step, at least a part of the reinforcing bead with a wall thickness greater than the wall thickness of the radius prior to the second deformation step.

3. A method as claimed in claim 1 or claim 2, characterised in that the central portion is gripped during the second deformation step.

4. A method as claimed in any preceding claim, characterised in that the flange is gripped during the second deformation step.

5. A method as claimed in any preceding claim, characterised in that said first deformation step takes place in two stages, said first stage comprising turning the peripheral portion of the blank through approximately a right angle to form a skirt for the blank and said second stage comprising drawing the central portion relative to the skirt, which skirt is carried over an abutment member to transform it into the annular flange.

6. Apparatus for forming a reinforced pressure-resistant can end comprising means for creating a substantially circular planar metallic blank having a central portion and a peripheral portion, first force exerting means for exerting first forces against either the peripheral portion or the central portion of the blank in a first direction, first abutment means against which the central portion or the peripheral portion of the blank respectively abut during operation of the first force exerting means to deform the peripheral and central portions relative to one another, so that the portions are offset out of a common plane, thus shaping the blank into a generally flanged cup-shaped configuration defined by the central portion, a radius, a frusto-conical wall and an annular flange, second force exerting means for exerting second forces against either the flange or the central portion in a second direction opposite the first direction, and second abutment means against which the central portion or the flange respectively abut during operation of the second force exerting means to deform at least part of the metal of the radius in the absence of restraint out of the plane of the central portion and to a side thereof opposite the annular flange, thereby forming an annular reinforcing countersink radius, characterised in that the first and second force exerting means and first and second abutment means are all coaxial and are located at the same work-station.

7. Apparatus as claimed in claim 6, characterised in that both said first and said second forces are exerted either against the peripheral portion of the blank and the annular flange respectively or against the central portion of the blank and the central portion of the cup-shaped configuration respectively.

8. Apparatus as claimed in either claim 6 or claim 7, characterised in that either the first force exerting means or first abutment means for cooperation with the central portion of the blank comprise a pair of spaced, coaxial shoulders for forming a work-hardened edge region and stretched central region of the radius.

9. Apparatus as claimed in any of claims 6 to 8, characterised in that the second force exerting means or second abutment means for cooperation with the interior surface of the central portion of a cup-shaped configuration is contoured at its periphery to define with the other of the said second force exerting means or second abutment means an annular cavity selected to form therein a reinforcing bead of a predetermined radius of curvature.

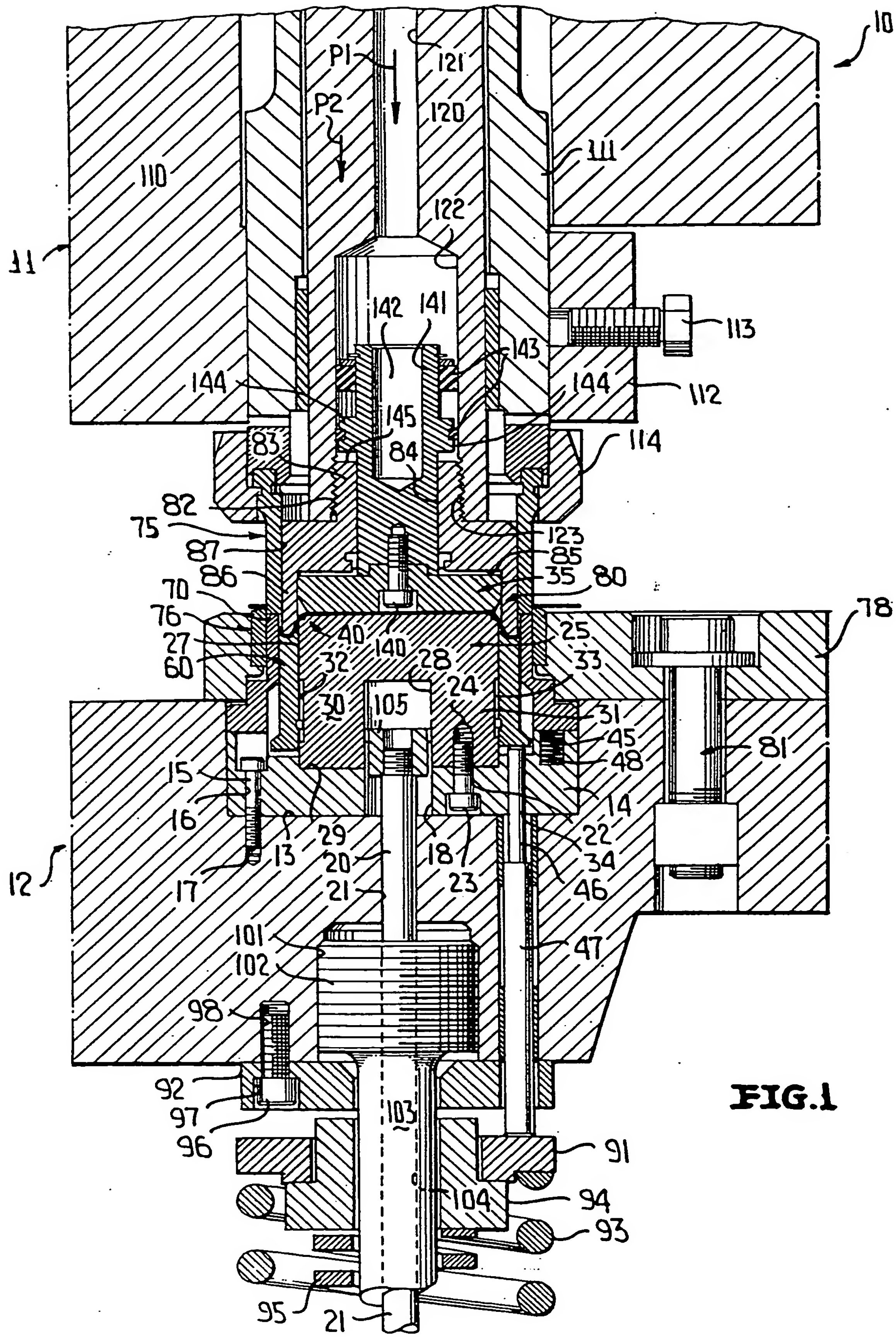
10. Apparatus as claimed in any of claims 6 to 9, characterised in that, during operation of the second force exerting means, the second abutment means co-act with a further abutment means to grip therebetween either the central portion of the cup-shaped configuration or the flange.

11. A reinforced pressure-resistant can end, comprising a metallic blank having a generally circular centre panel, a panel radius joining the centre panel to a generally frusto-conical peripherally inner wall converging in a direction towards said panel radius and defining therewith and with said centre panel a generally interior frusto-conical chamber subject to internal pressure when the can end is flanged to an associated can body, an annular exteriorly opening reinforcing countersink radius joining said frusto-conical peripherally inner wall with a generally frusto-conical peripherally

outer wall, said frusto-conical walls being in diverging relationship relative to each other in a direction away from said countersink radius, said outer frusto-conical wall merging with a flange adapted to be seamed to a can body, said metallic blank having a nominal unformed thickness reflected by the cross-sectional thickness of unformed portions of said centre panel, characterised in that at least a portion of the cross-sectional thickness of said countersink radius is greater than the cross-sectional thickness of the unformed portions of said centre panel.

12. A can end as claimed in claim 11, characterised in that said greater thickness portion of the countersink radius is immediately adjacent said outer frusto-conical wall.

13. A can end as claimed in claim 11 or 12, characterised in that there is a flexible annular wall portion between said circular centre panel and said panel radius, and said flexible annular wall portion progressively thins in cross-sectional thickness from said circular centre panel to said panel radius, thereby transferring forces which might otherwise cause undesired distortion on use and/or impact of the can.


10
P1
121
P2
120
111
110
122
11
142
141
113
143
144
144
112
145
83
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114
82
123
75
87
85
86
35
80
70
78
76
40
140
28
25
27
32
33
60
24
30
105
31
45
48
81
15
14
16
13
29
18
22
20
23
34
17
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46
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91
104
94
93
95
21

FIG.1

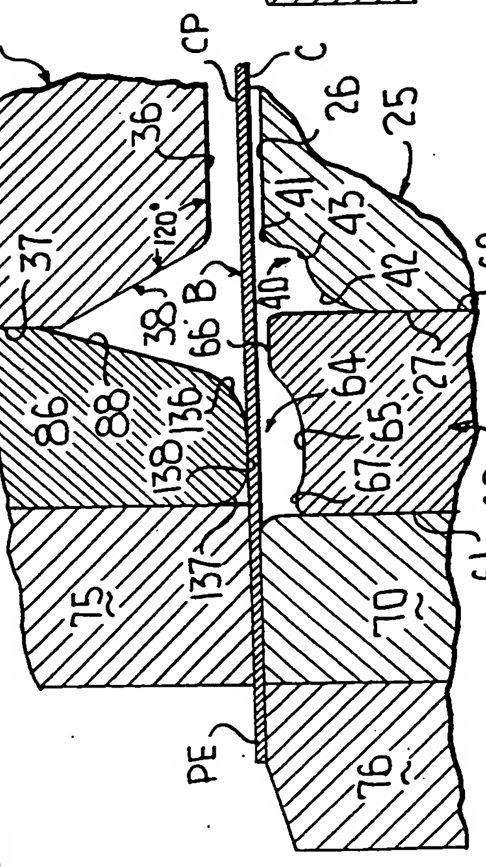



FIG.2

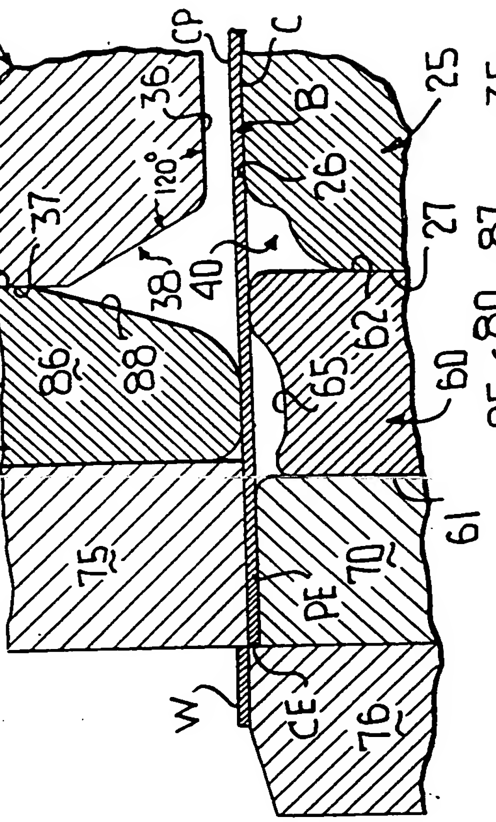



FIG.3

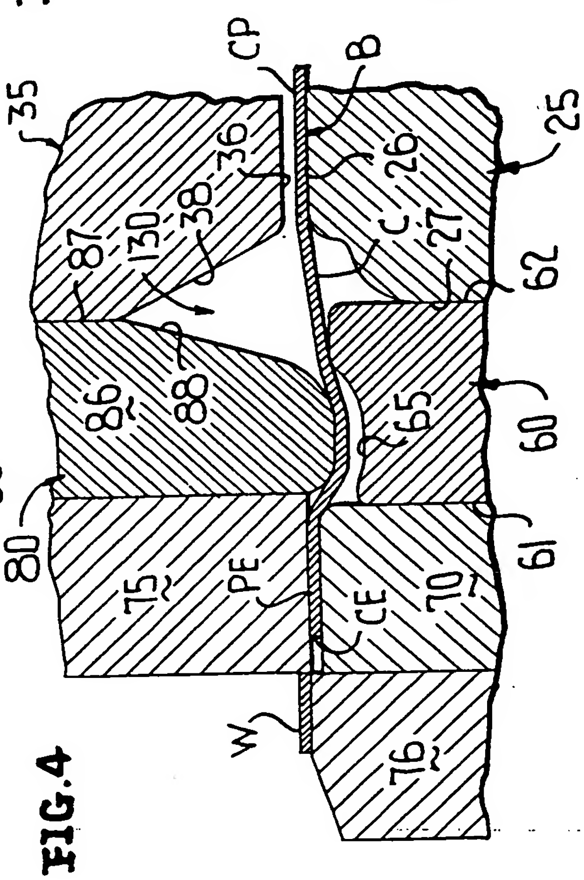



FIG.4

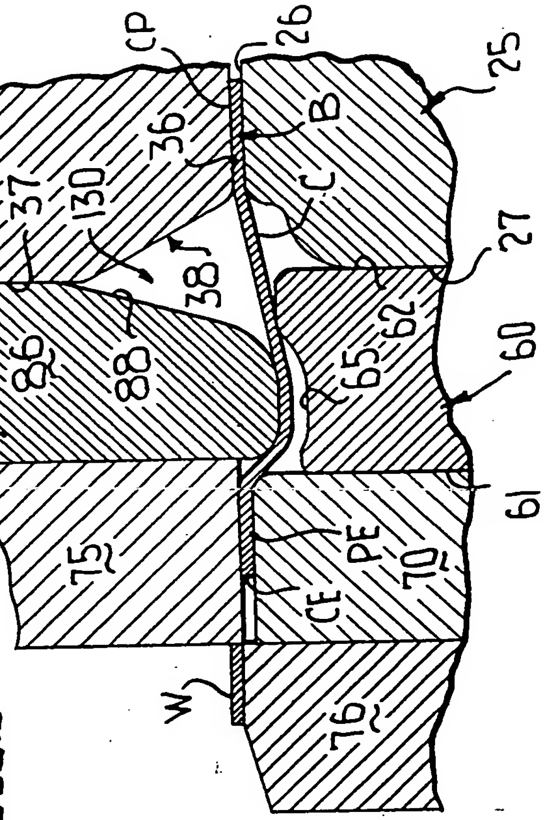



FIG.5

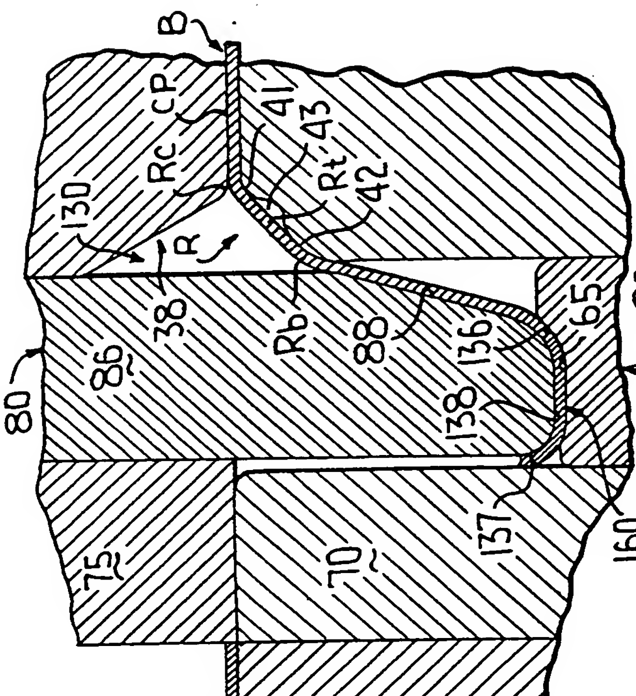



FIG.7

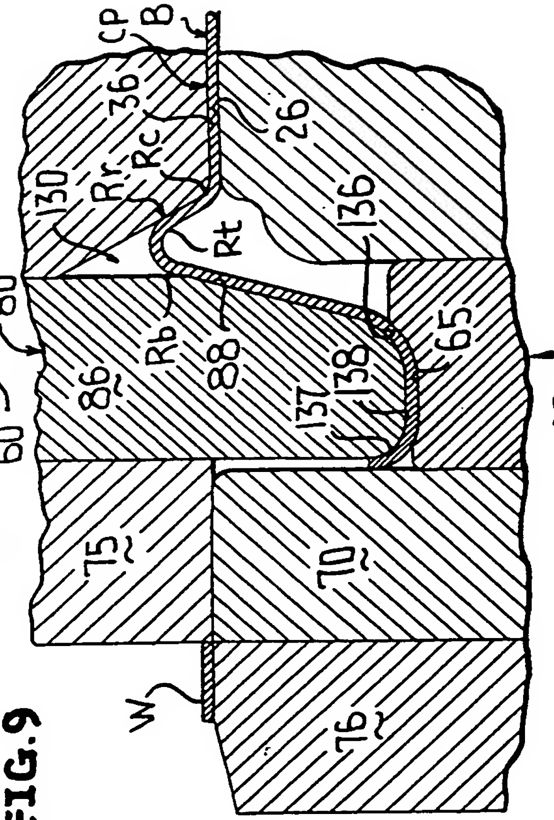



FIG.9

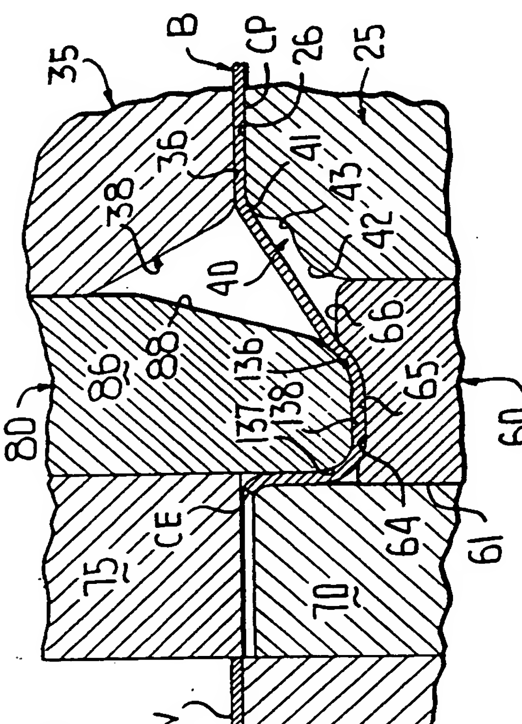



FIG.6

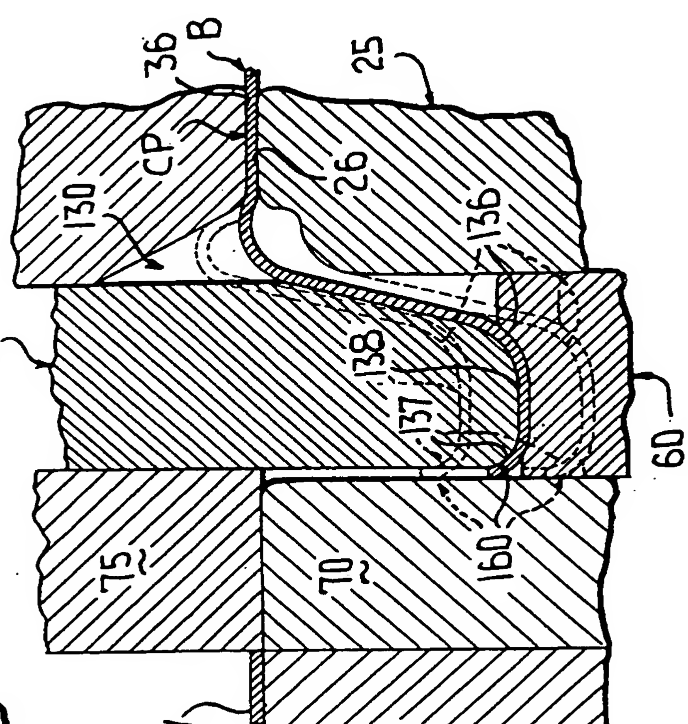
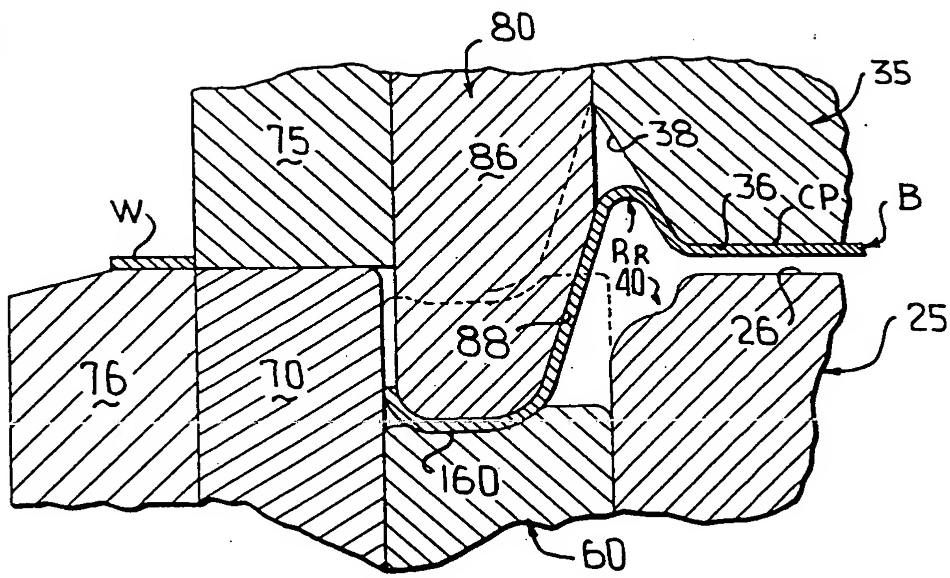
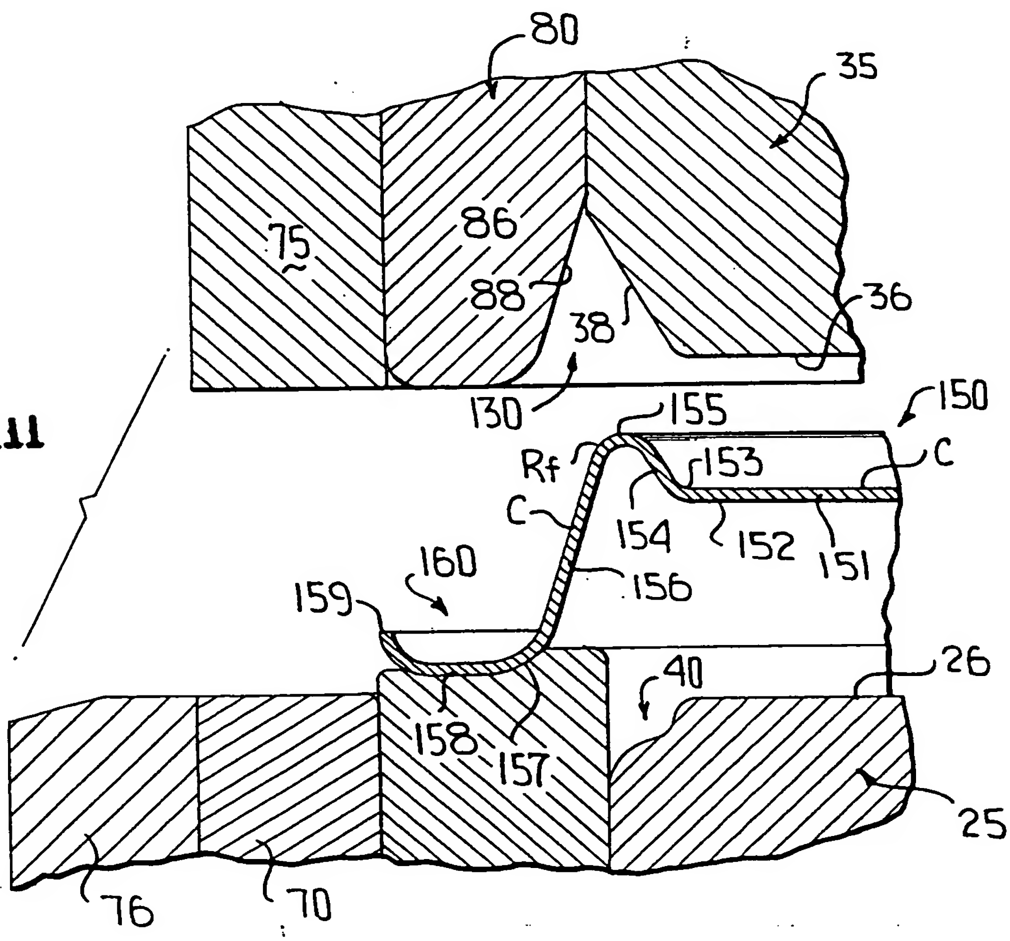



FIG.8

FIG.10


80
35
75
86
38
36
CP
B
W
RR
40
26
25
76
70
88
160
60


80
35
75
86
88
38
36
130
155
150
Rf
153
C
C
154
152
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160
156
159
40
26
158
157
25
76
70

FIG.11

FIG.12

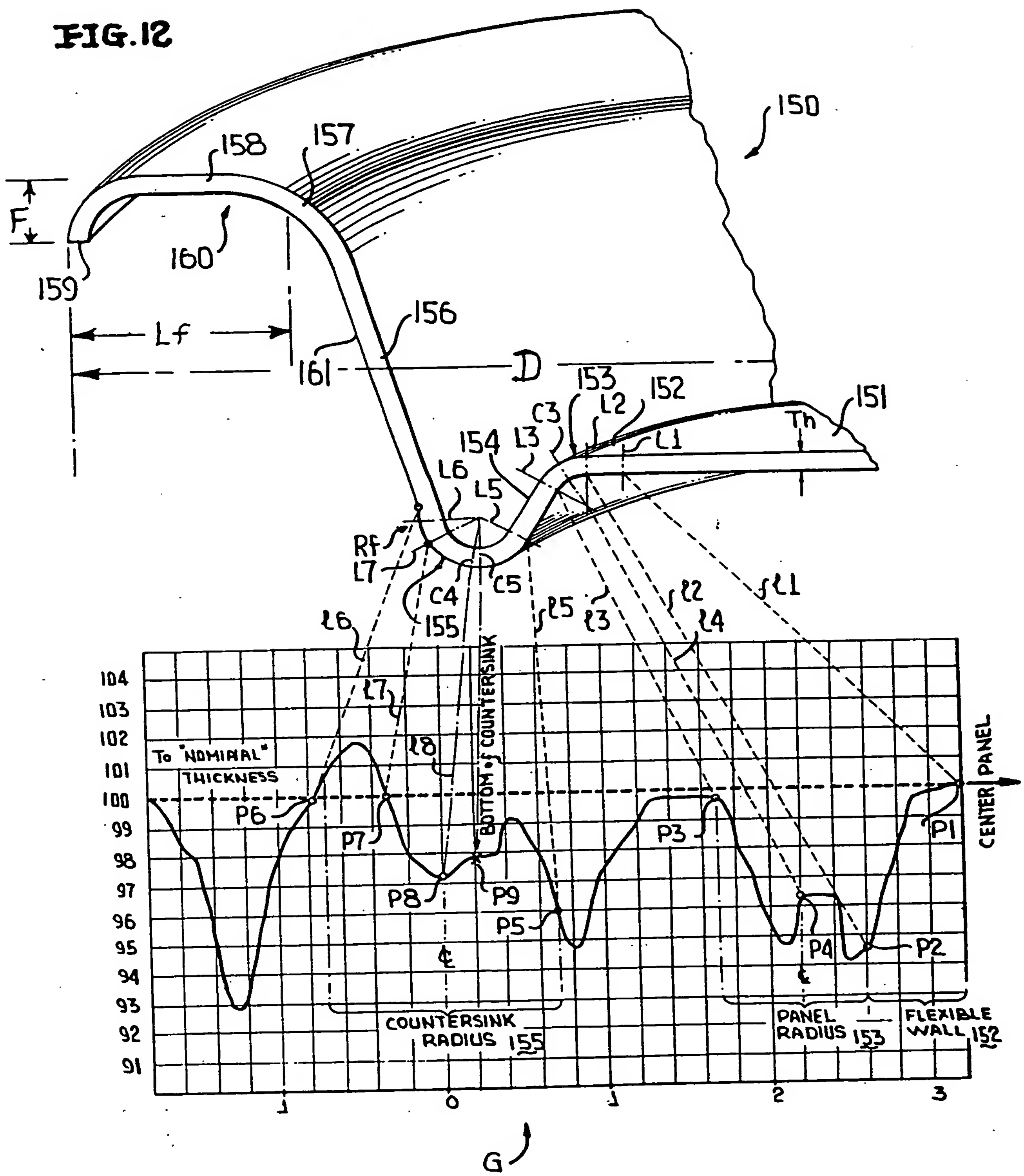

150
151
152
153
154
155
156
157
158
159
160
161
F
Lf
D
Th
Rf
L1
L2
L3
L5
L6
L7
C3
C4
C5
ℓ1
ℓ2
ℓ3
ℓ4
ℓ5
ℓ6
ℓ7
ℓ8
To "NOMINAL" THICKNESS
BOTTOM of COUNTERSINK
CENTER PANEL
P1
P2
P3
P4
P5
P6
P7
P8
P9
COUNTERSINK RADIUS 155
PANEL RADIUS 153
FLEXIBLE WALL 152
104
103
102
101
100
99
98
97
96
95
94
93
92
91
1
0
1
2
3
G

FIG.14

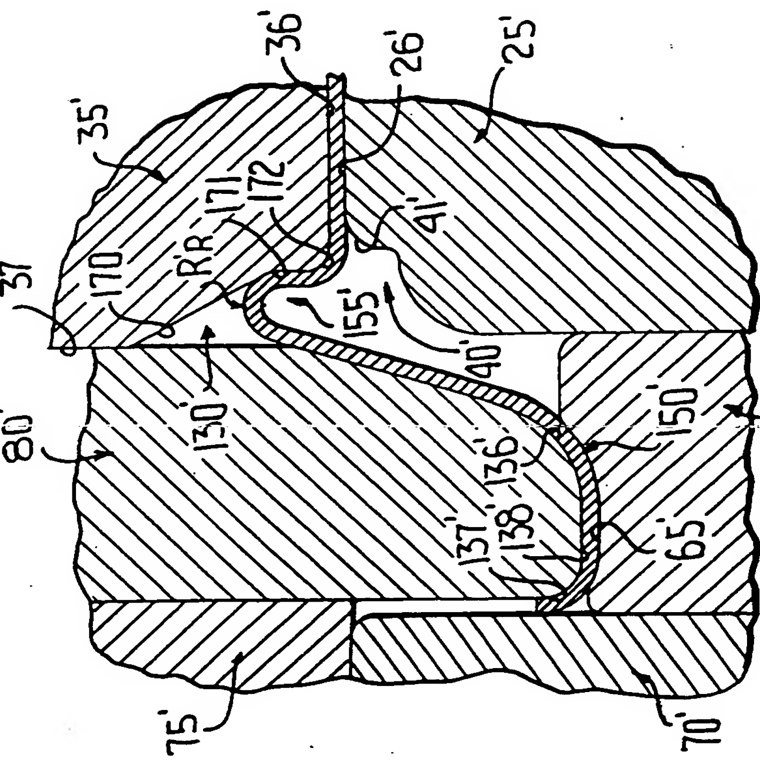
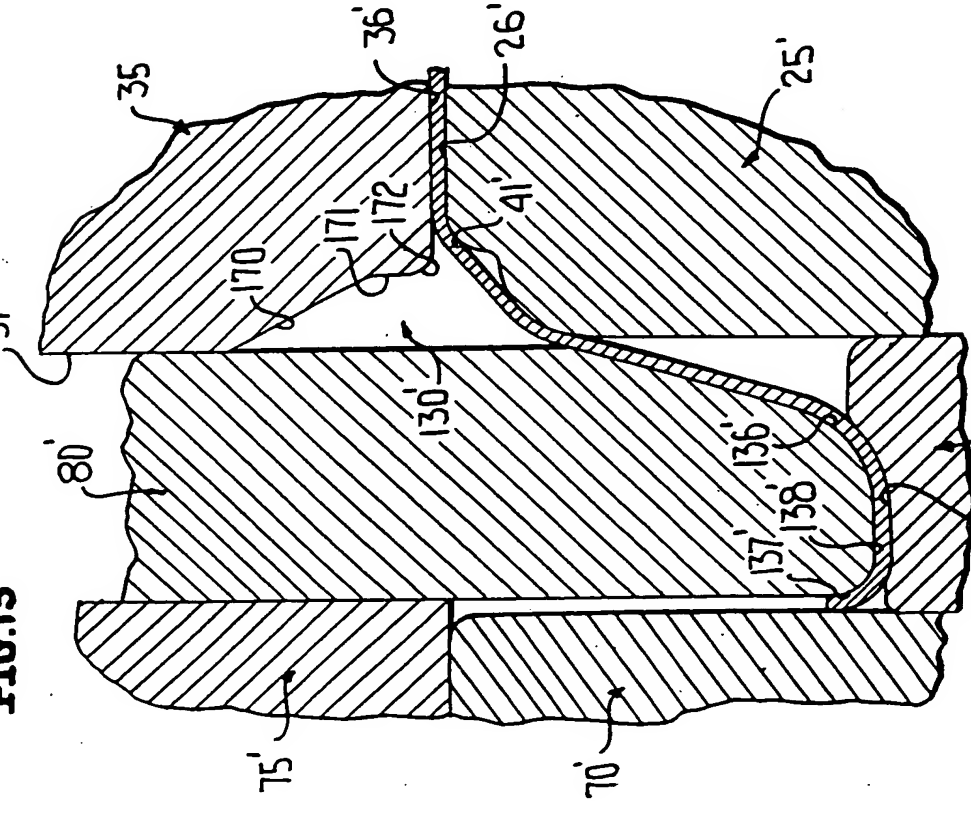
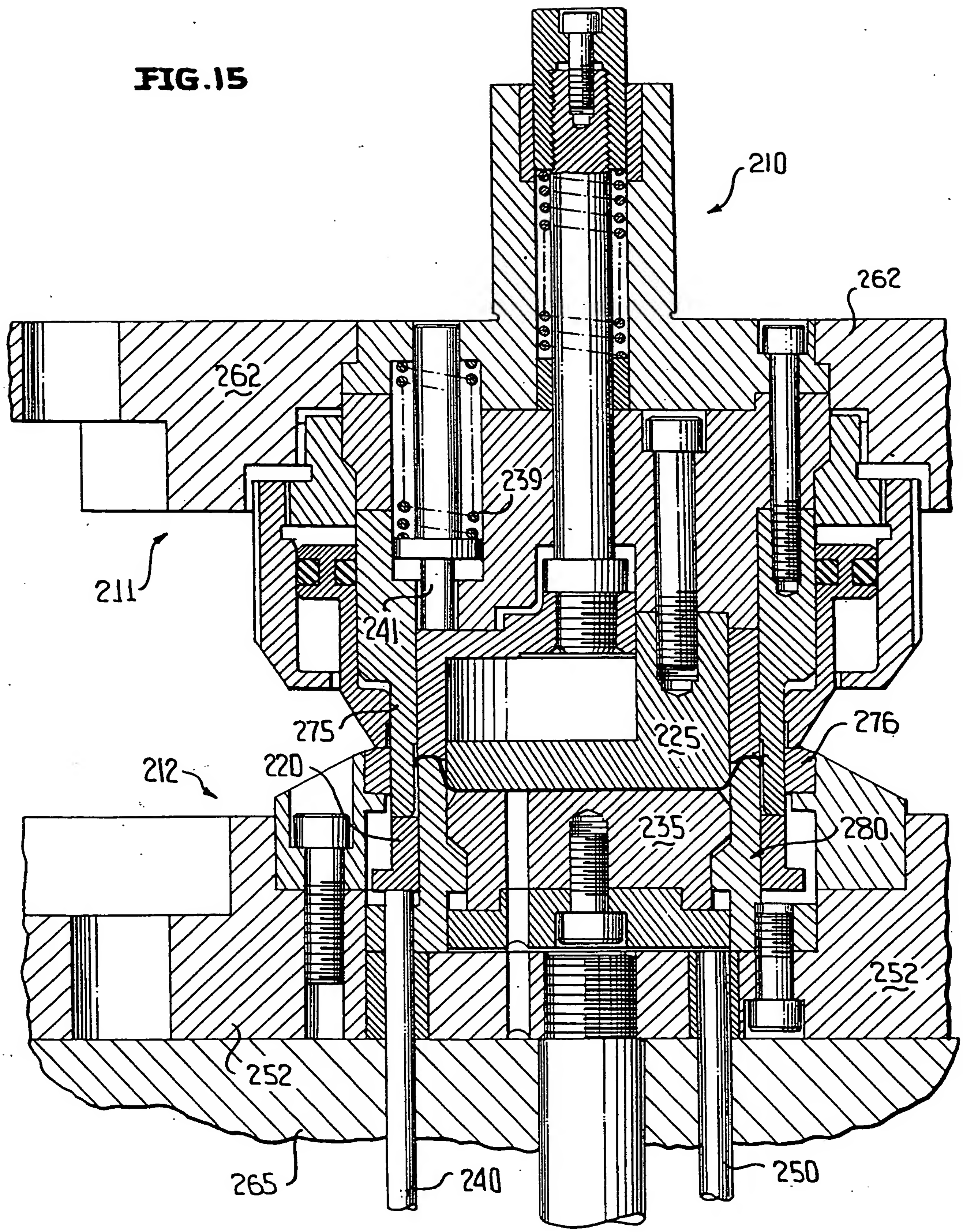

35'
36'
26'
25'
37'
170
RR
171
172
41'
155'
40'
130'
80'
150'
136'
137'
138'
65'
60'
75'
70'

FIG.13


35
36'
26'
25'
37'
170
171
172
41'
130'
80'
60'
136'
138'
137'
65'
75'
70'


210
262
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239
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235
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265
240
250

FIG.15

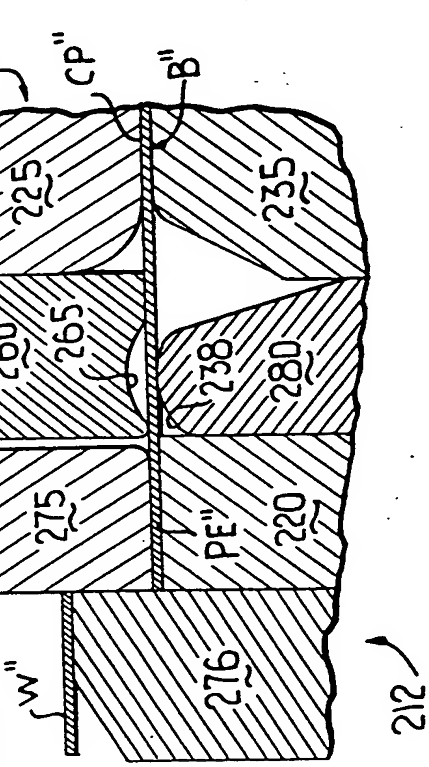


FIG.16

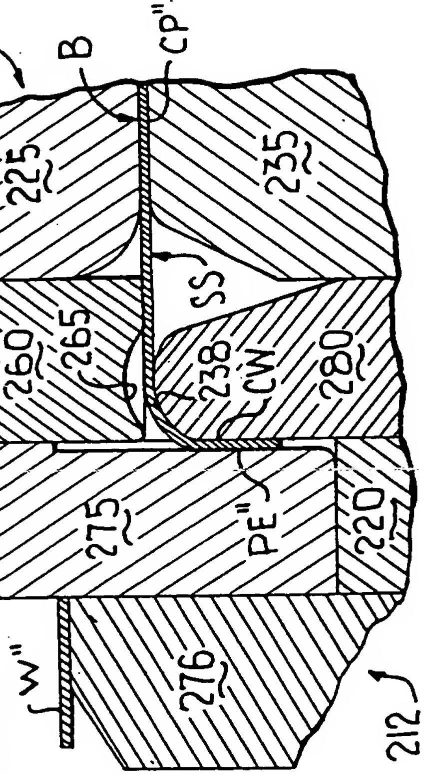


FIG.17

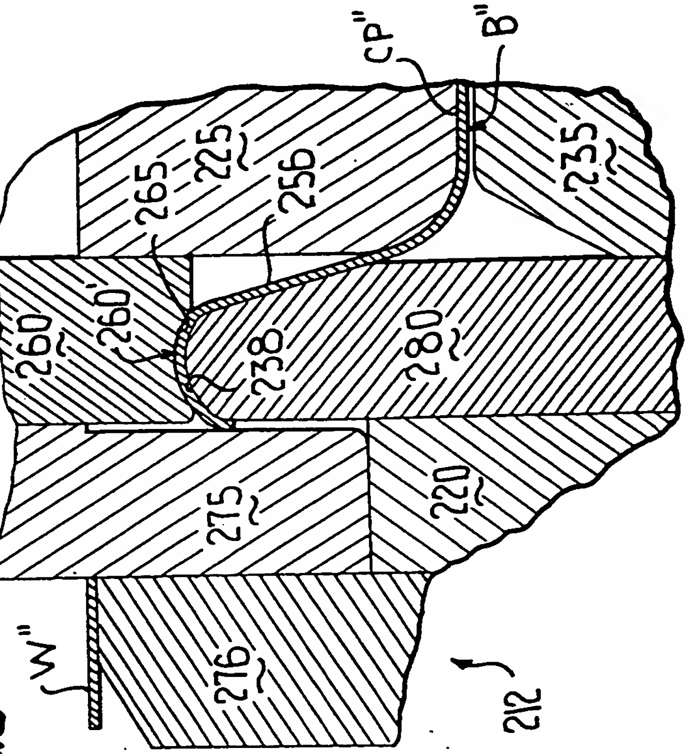


FIG.18

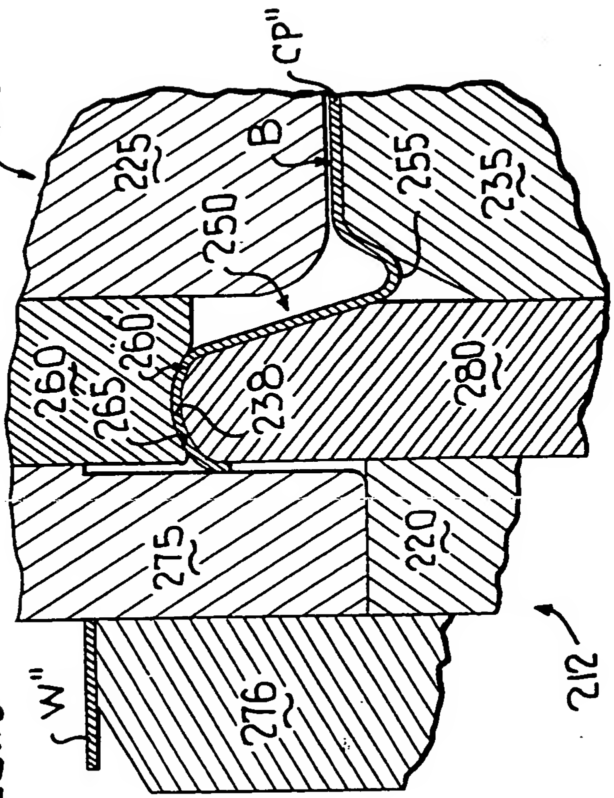


FIG.19